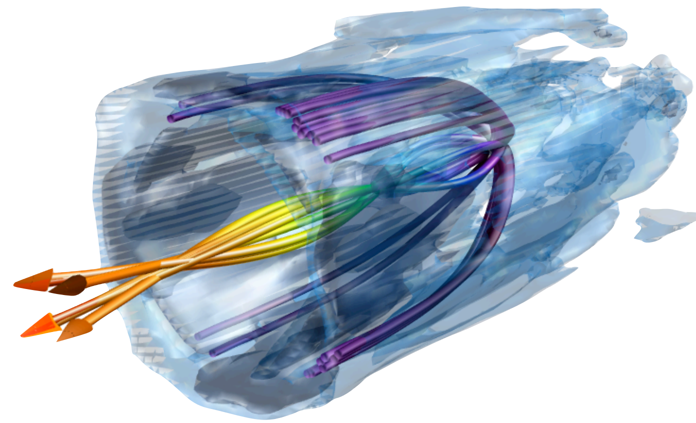
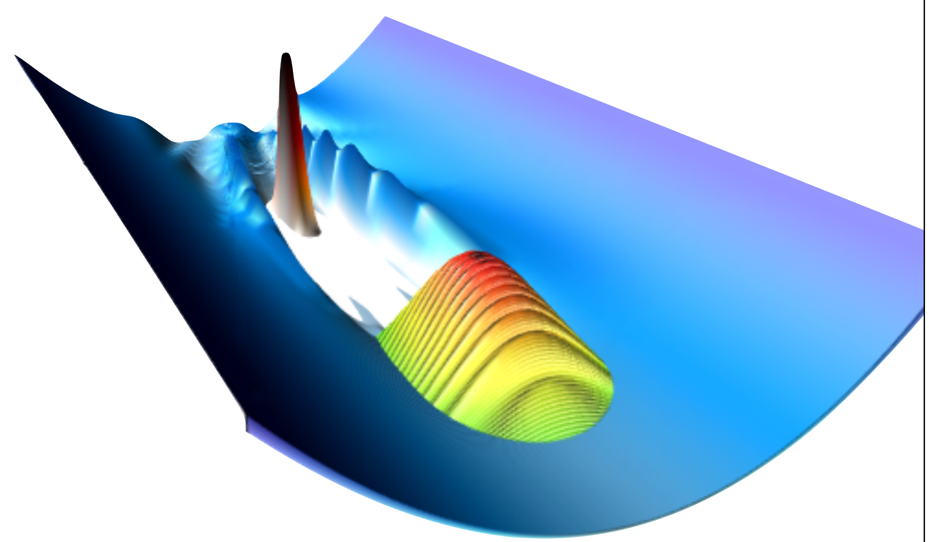
# Needs for other LWFA concepts and experiments



UCLA



# Goals of OSIRIS/QuickPIC LWFA effort

- Blowout regime (not bubble regime)
  - a_0=2~20
  - For both HEP and light sources
- Supporting UCLA and LLNL/UCLA experiments
  - Self-guiding
  - Ionization trapping
- Supporting other experiments
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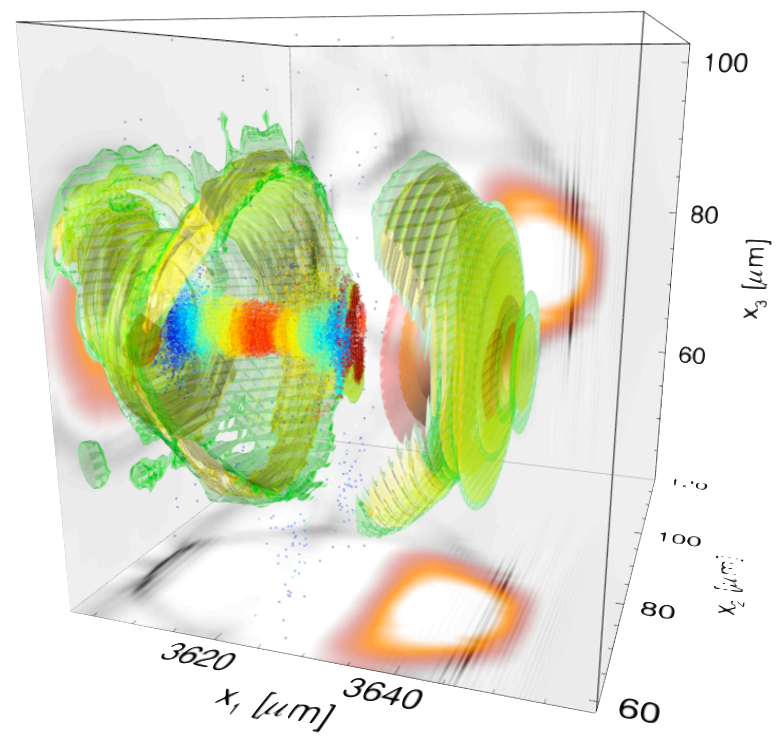
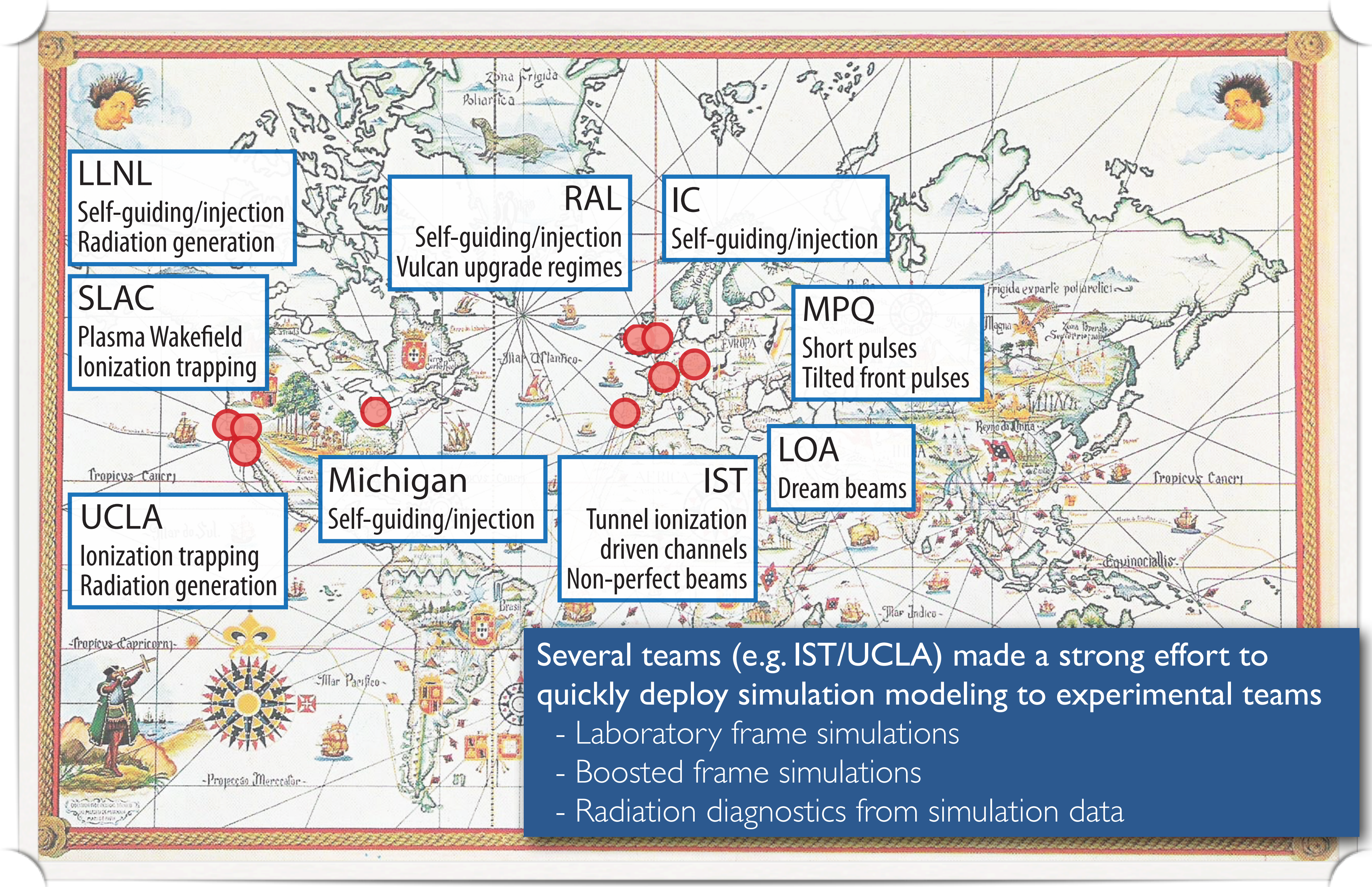
- Real-time steering of experiments




- Challenges
  - Verification and validation
  - Emittance/energy spread/charge
  - Speeding up turn around time

# Supporting Experiment Design with OSIRIS

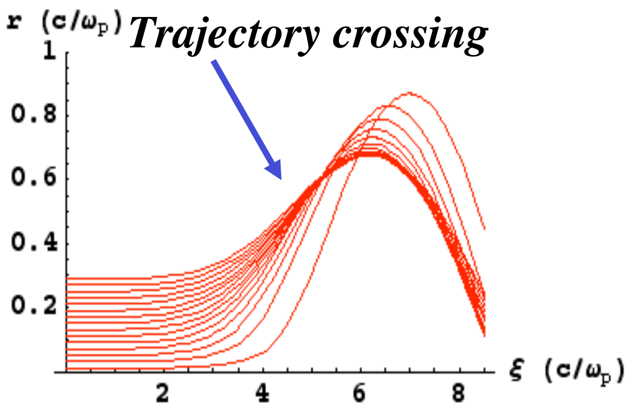



Several teams (e.g. IST/UCLA) made a strong effort to quickly deploy simulation modeling to experimental teams

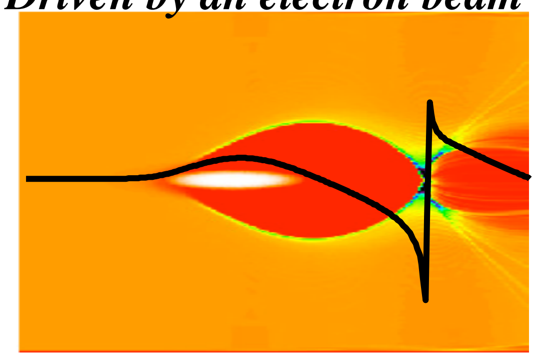
- Laboratory frame simulations
- Boosted frame simulations
- Radiation diagnostics from simulation data

# UCLA Blowout and Bubble regimes: Requires PIC simulations

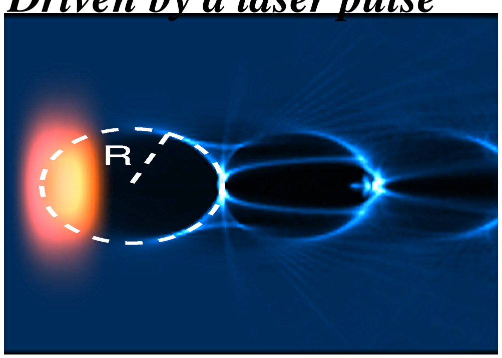
**Rosenzweig et al. 1990, Puhkov and Meyer-ter-vehn 2002, Lu et al. 2006, 2007**




*Driven by an electron beam*



*Driven by a laser pulse*




- **Ion channel formed by crossing**
- **Ideal linear focusing force**
- **Uniform acceleration**
- **Fluid model breakdown!**
- **2D/3D and electromagnetic in nature!**
- **Provides stable wakes and lasers**

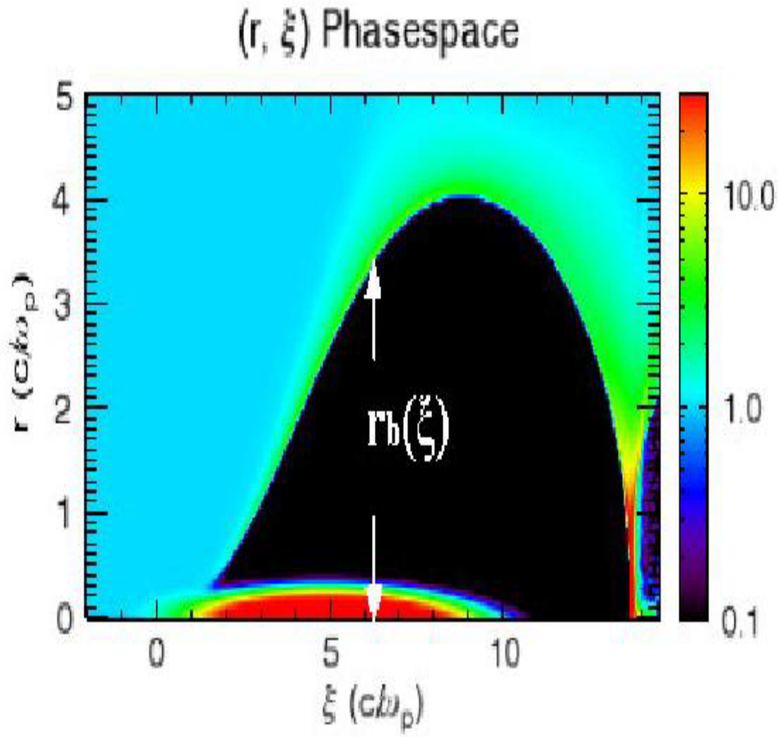
***What do we want to know?***

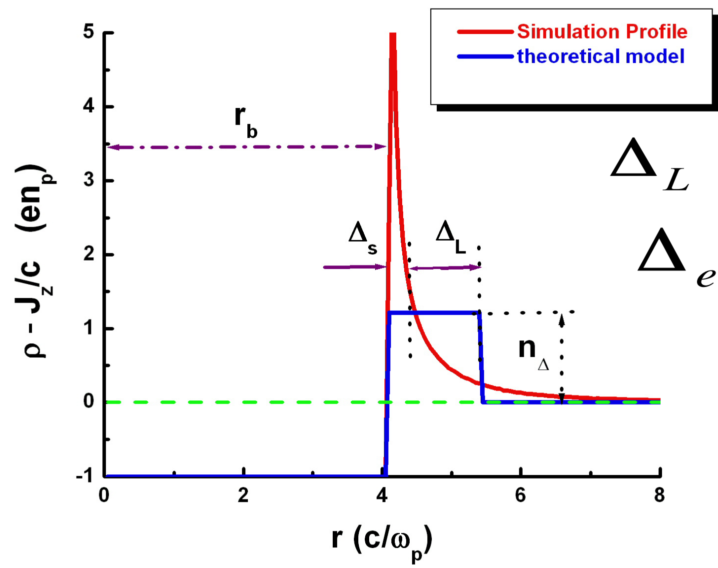
- **Wake excitation for given drivers ……**
- **Beam loading, transformer ratio ……**
- **Instabilities ……**
- **Self-injection, wave breaking ……**
- **How to choose parameters for a real LWFA accelerator?**
- **How does one accelerate positrons?**

# A phenomenological theory  for wake excitation

Lu et al., PRL 96, 165002, 2006

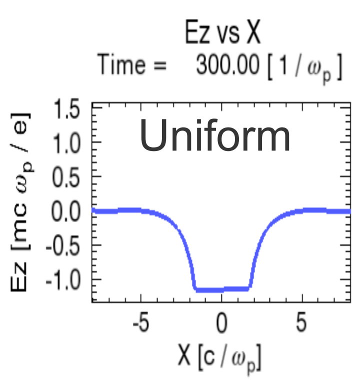
## Ion column  +  sheath +  linear region

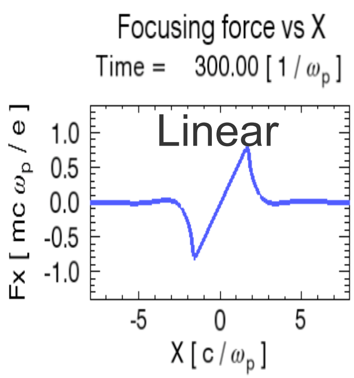



$$\Delta_L \sim c/\omega_p$$

$$\Delta_e << r_b$$




**Ultra-relativistic blowout**

$$r_b >> 1(>\sim 4)$$

$$r_b \frac{d^2 r_b}{d\xi^2} + 2\left(\frac{dr_b}{d\xi}\right)^2 + 1 = 0$$

**Nearly a circle!**

# LWFA in a controlled nonlinear blowout regime: a_0=2~10

The accelerating structure needs to remain as stable, for this purpose we choose the laser spot size and intensity from the condition :

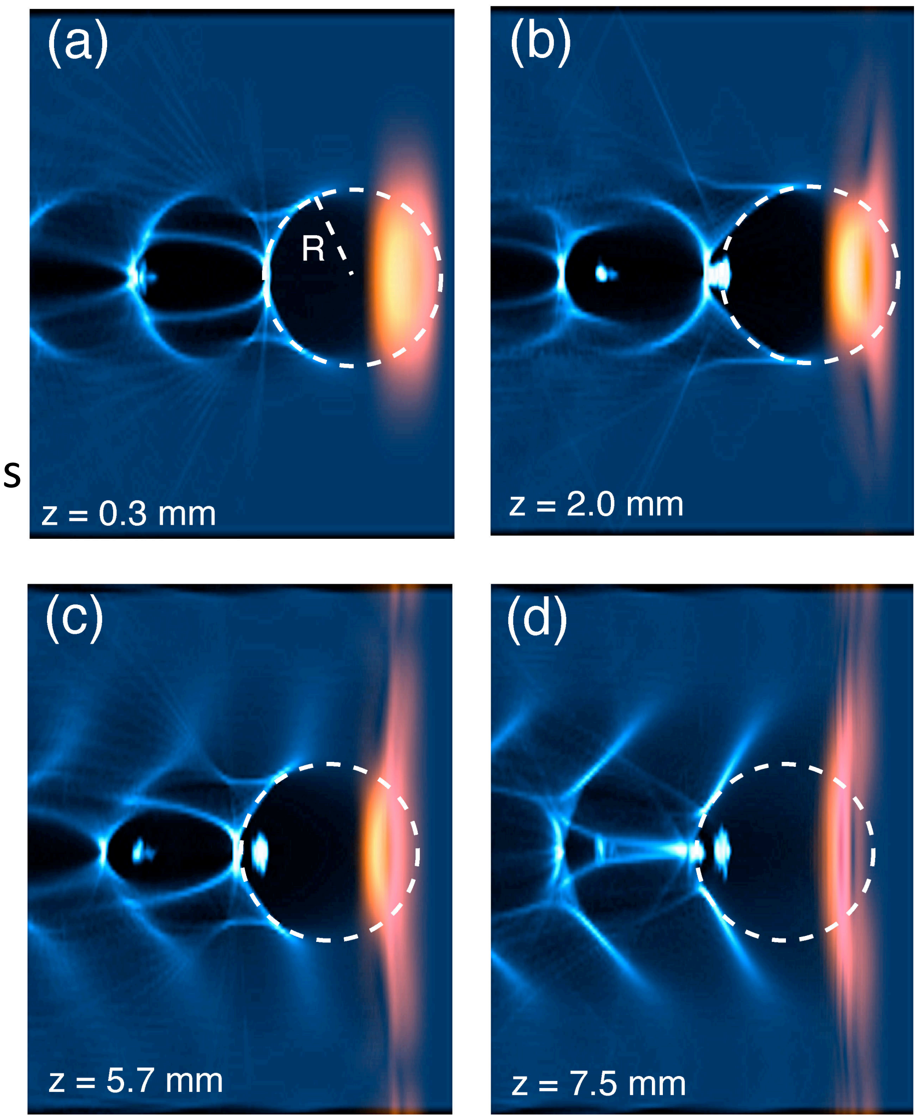
$$\begin{bmatrix}\text{Matched}\\ \text{profile}\end{bmatrix}:\ k_p w_0 \approx k_p R_b \approx 2\sqrt{a_0} \Rightarrow a_0 \approx 2\left(\frac{P}{P_c}\right)^{1/3}$$

The accelerating field in the ion channel decreases linearly from the front reaching minimum value with magnitude:

$$\begin{bmatrix}\text{Maximum}\\ \text{field}\end{bmatrix}:\ \frac{eE_M}{mc\omega_p} \approx \frac{1}{2} k_p R_b \approx \sqrt{a_0}$$

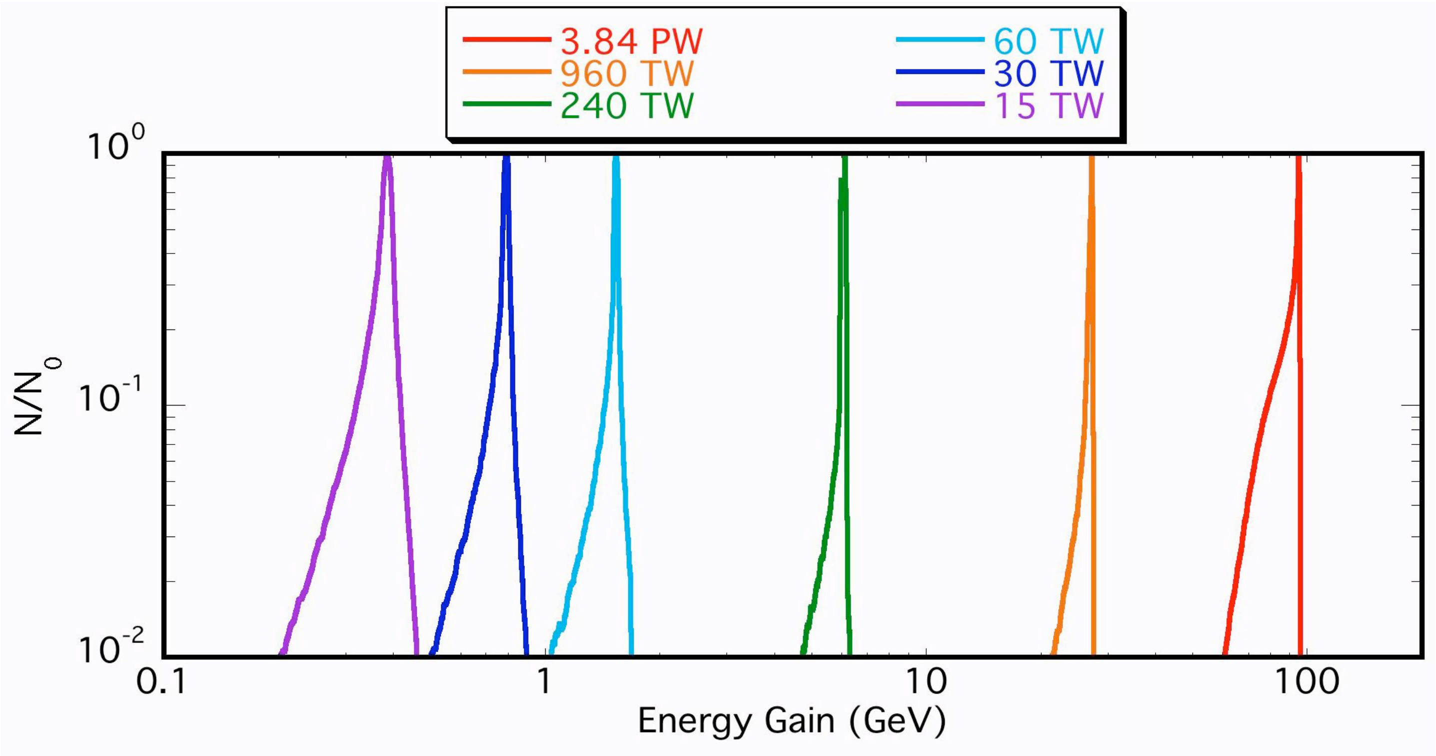
The acceleration process is limited by dephasing:

$$\begin{bmatrix}\text{Acceleration}\\ \text{distance}\end{bmatrix}:\ \begin{matrix} a_0 > 1 \\ L \approx R_b \end{matrix} \Rightarrow L_{etch} \geq L_\phi \approx \frac{4\sqrt{a_0}}{3k_0}\left(\frac{k_0}{k_p}\right)^3$$



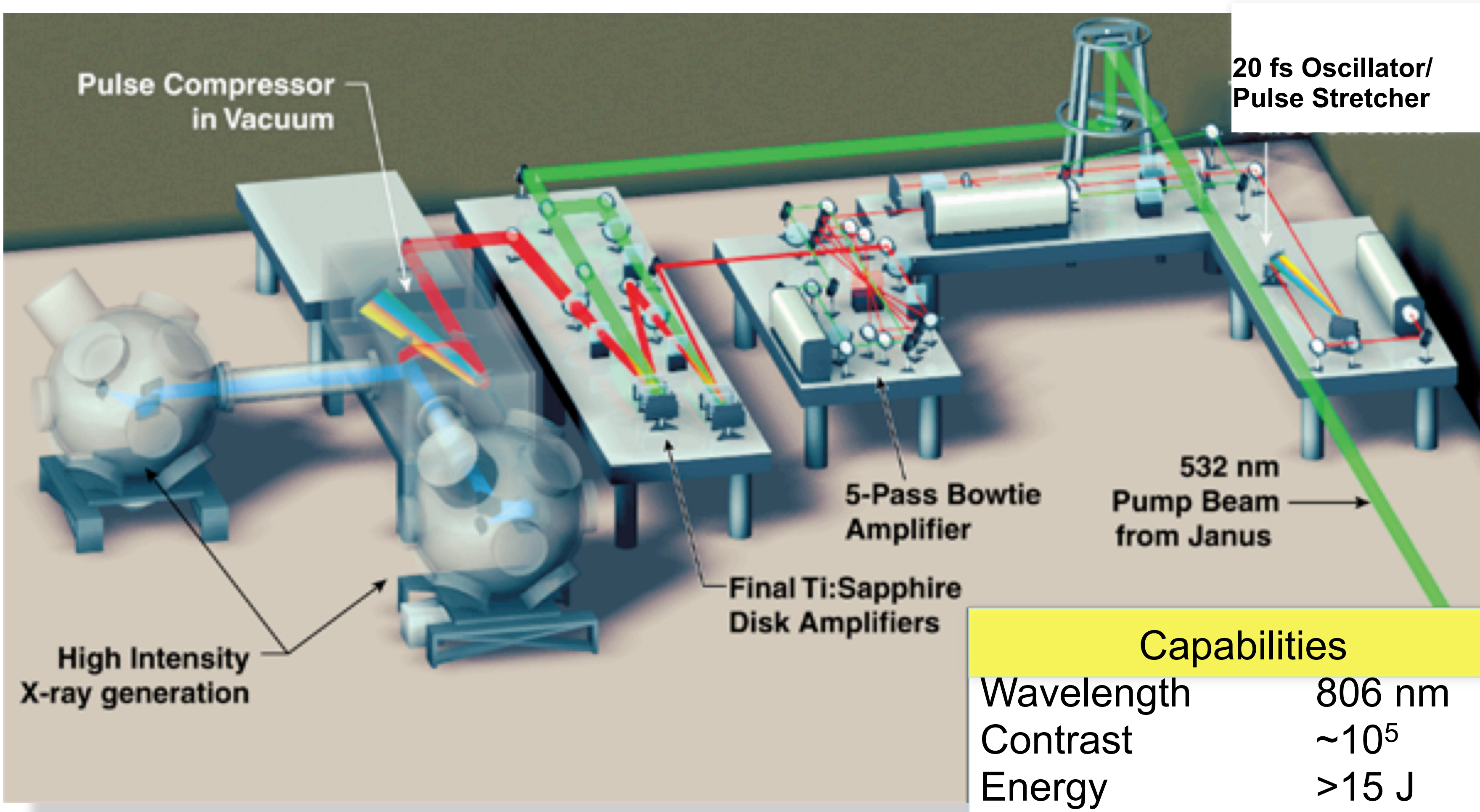
UCLA

# Using QuickPIC to scale up using theory of Lu et al.




- The emittance remains relatively constant throughout all of the simulations.
- To reduce the energy spread an exact theory is required for beam loading and for the evolution of the laser after hundreds of $Z_R$.

# The UCLA/LLNL collaboration is using the 200 TW Callisto Laser Facility at the Jupiter Laser Facility for LWFA experiments




| Capabilities | |
|---|---|
| Wavelength | 806 nm |
| Contrast | $\sim 10^5$ |
| Energy | >15 J |
| Pulsewidth | <60 fs |
| Rep rate | 2/ hour |

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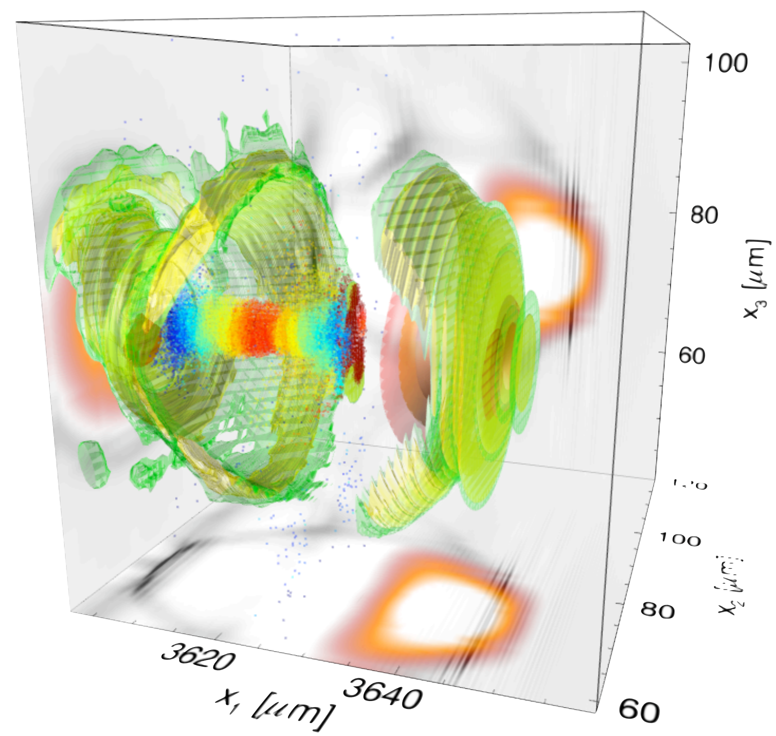


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